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ATLAS 4151
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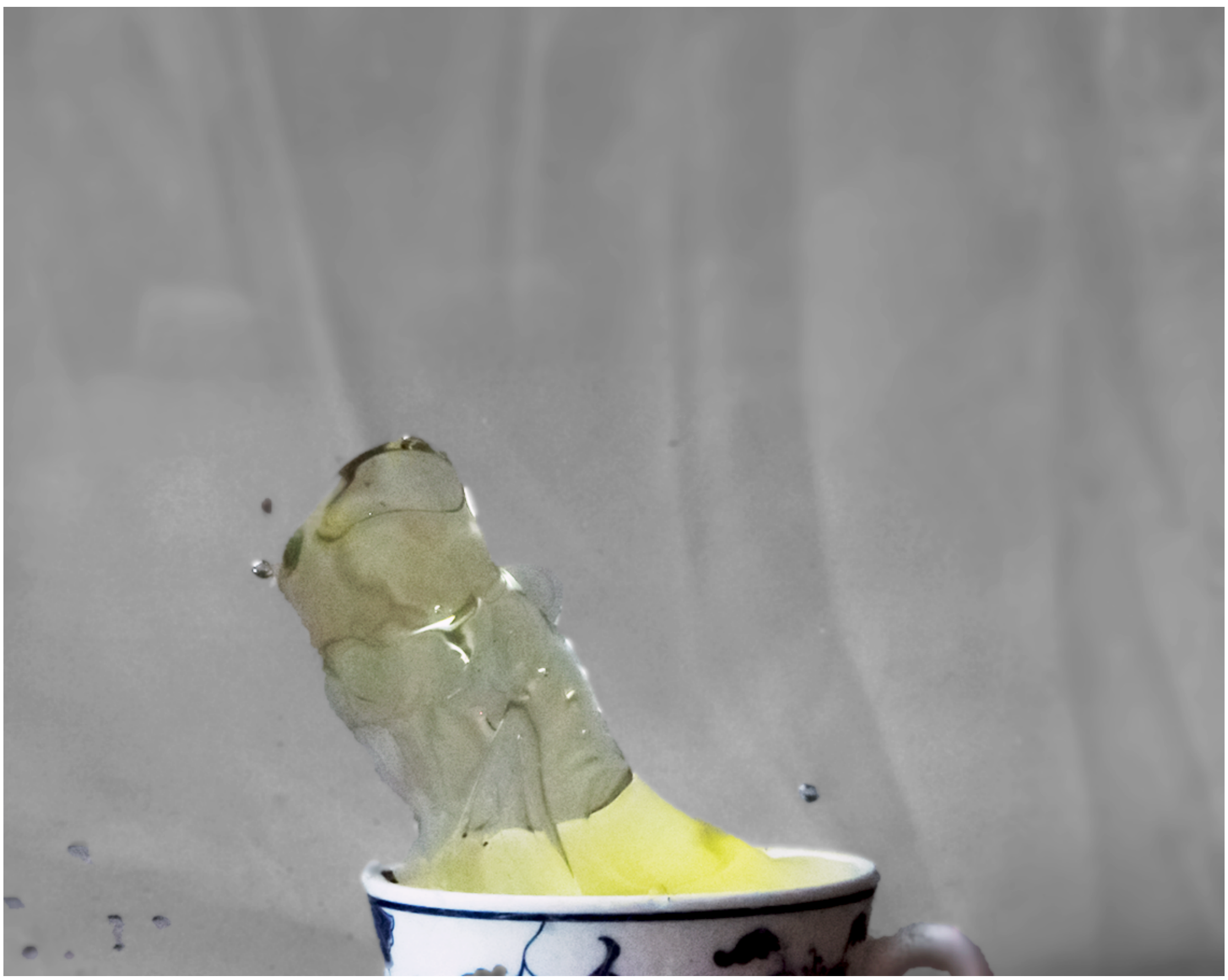
Image One



Introduction

This project's original goal was to capture the effects of the Reighley Taylor Instability. Although, upon assessing the images captured, the focus pivoted toward creating a unique and surreal image displaying the Reighley Taylor Instability. The intent behind this focus was to create an image that could not immediately be intuited, forcing the viewer to more closely grapple with the fluid dynamics at play.

Set Up

In order to create the image, an approximately 200ml tea cup was filled to overflowing with Kroger's brand vegetable oil and covered with a glass plate. This would then be submerged in a 2m x 0.5m x 0.5m fish tank filled completely with water. The weight of the glass plate and the ambient pressure of the water held the plate on top of the tea cup as it sat at the bottom of the fish tank. Once the tea cup was in position, the camera position was adjusted to ensure adequate focus. Finally, the plate was slid off the top of the tea cup, moving such that it remained parallel to the bottom of the fish tank, releasing the oil and resulting in the final image.

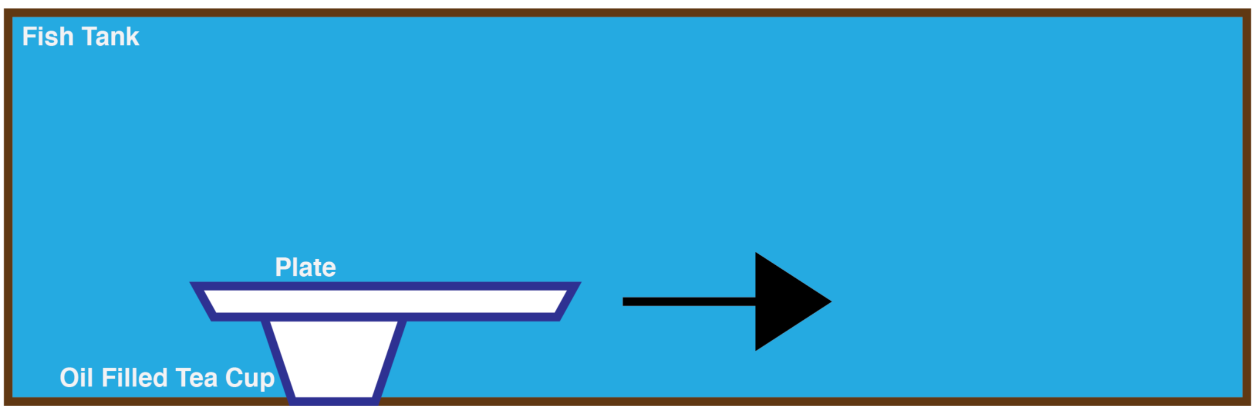


Figure 1: Photo setup diagram

Fluid Dynamics

The Reighley Taylor Instability occurs when a fluid of lower density pushes against a fluid of higher density. In this case the vegetable oil is accelerated upward into the water by the buoyant force of the water. Growth of this instability is initially linear, but, as it grows larger, pressure and density gradients mis-align such that the sides of the fluid experience a torque, leading to the mushroom-like non-linear growth of the instability. The rate at which this transition occurs is related to the Atwood number, which is found by taking the difference of the two fluid's densities divided by the sum of those densities. For an Atwood number close to one, instabilities will rapidly plume out in a non-linear fashion, and for an Atwood number close to zero, instabilities will remain linear for much longer. For vegetable oil and water, the Atwood number is approximately 0.04, thus the long linear phase observed in the photo is consistent with this measurement. Originally this set up was done with fluids far less dense than water, but in order to maintain the fluid's connection to the cup, it was necessary to remain in the linear phase of the instability, thus vegetable oil was chosen for its almost water like density to give a much lower Atwood number.

$$A=(p_{heavy}-p_{light})/(p_{heavy}+p_{light})$$
$$A=(1\ g/cm^3-.92g/cm^3)/(1\ g/cm^3+.92g/cm^3)$$
$$A\approx 0.042$$

Figure 2: Atwood number calculations for oil in water

Visualization

The only visualization technique used in this setup is the seeded boundary between the vegetable oil and water. Most of the visual, clarity enhancements were done via post processing. In order to avoid any glare in the water or the glass of the fish tank, this picture was taken outside, shortly before sunset. No Flash or external lights were used to light the image, simply the well dispersed light of the sun.

Photographic Technique

Figure 3: Raw image before post processing.

This image was taken from 1m away with a similar focal length of 1m, an aperture of F22, a shutter speed of 1/800th of a second, and an ISO of 2500. The intention of this setup was to ensure that the image would be in focus no matter how fast or sporadically the vegetable oil moved through the water. Unfortunately, due to how little light this setup took in, the ISO had to be raised in compensation. This resulted in a grainy, and admittedly still dark, image. In order to enhance the raw image, changes were made in post via photoshop. First, the noise of the high ISO was removed via the grain reduction feature. This was followed by the creation of two masks, one for the foreground and one for the background. The background was desaturated and blurred to remove the presence of the water and shift focus to the oil. The yellow of the vegetable oil was enhanced and the lighting of both masks was adjusted to a brighter level. This allowed the image to create the desired surreal effect and maintain the sharpness of the raw image without suffering from its noise and low light levels. The final image was also cropped to remove my hand, and unnecessary white space from the background.

Conclusion

This image demonstrates the linear phase of a Reighley Taylor Instability in a very surreal manner. The phenomena is very clearly the center of the photo, but without reading the images companion description, it would appear that the Reighley Taylor Instability is propagating from a higher density fluid being accelerated into a lower one. This may obscure the physics at play initially, but it also encourages the viewer to grapple with the full extent of fluid dynamics at play. As such I believe I successfully fulfilled my intent to highlight the Reighley Taylor Instability in an interesting and surreal manner. If I were to recreate or improve on this image, I likely would have made more concessions in image sharpness to obtain better light and lower ISO. The use of aggressively high aperture and shutter speed ultimately resulted in the loss of more detail than expected due to the need for aggressive post processing. In the future, this setup could be used to take interesting photos contrasting how fluids of different Atwood numbers behave in a Reighley Taylor Instability.

Bibliography

Sharp, D. H. “Overview of Rayleigh-Taylor Instability.” *Fronts, Interfaces and Patterns Conference, Los Alamos, NM, USA, 2 May 1983*, 1 Jan. 1983, digital.library.unt.edu/ark:/67531/metadc1104671/. Accessed 27 Sept. 2021.